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Bill Sheffield, Governor

Annual Performance Report for

INTERIOR BURBOT STUDY, PART C: HOOP TRAP CATCH PER UNIT EFFORT STANDARDIZATION

by

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RESEARCH PROJECT SEGMENT

State: Alaska

Name: Sport Fish Investigations of Alaska

Project: F-10-1

Study: N-8

Study Title: NORTHERN PIKE/ BURBOT

Job No: N-8-1

Job Title: Interior Burbot Study

Part C: Hoop Trap Catch Per Unit Effort Standardization

Cooperators: Gary A. Pearse
Robert Conrad

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ABSTRACT

Research to develop a standard fishing methodology to allow catch per unit effort statistics to index burbot, *Lota lota* (Linnaeus), abundance was conducted during 1985 in Interior Alaska. Two lakes, Harding and Fielding and a section of the nearby Tanana River, between 63° and 65° North latitude and 145° and 148° West longitude, were sampled. A commercially available baited double-throated hoop trap, 3 feet diameter by 12 feet length was used for fish capture. This report documents findings relative to sampling methodology, baiting strategy, catch vs. depth, effort, photoperiod, and other factors found to influence catch per unit effort. The effects of handling burbot are discussed.

In Fielding Lake, frequency distribution of the catch per unit effort data were skewed significantly from the normal distribution due to the high incidence of zero catches in nets set for a single net-night compared with those set up to five net-nights. Catch per unit effort of nets during darkness was significantly higher than that of daylight sets. Baited traps were more effective than non-baited traps in capturing burbot, but, no difference between daily rebaiting and non-rebaited sets over two to five net-nights was noted. Nearly all burbot were caught during the first two net-nights of effort. No significant difference in mean catch was found between nets set from two to five net-nights. Depth of set significantly influenced catch. Nets set less than 20 feet caught fewer burbot than deeper sets. Burbot were captured more in deeper sets during July than in August and September.

Mean catch per set in Fielding Lake for two to five net-night sets was 2.39 in July, 1.58 in August and 2.58 in September. Estimated sample sizes required to achieve specified levels of precision for different mean index values with 90% and 95% confidence interval are presented.

During lake sampling, several mortality factors were observed. Air bladder expansion and embolism brought upon by pressure and temperature changes are discussed and possible solutions presented.

Catch per unit effort varied from 0.8 to 3.4 burbot per net-night in the Tanana River sections sampled. Traps rebaited and moved daily had the highest catch per unit effort (1.7 per net-night). Catch rates declined after one net-night for traps not moved. Captured burbot retained in hoop traps in the Tanana River showed physical damage after two net-nights.

KEY WORDS

Abundance, burbot, depth distribution, Fielding Lake, fishing gear, Harding Lake, hoop traps, *Lota lota*, seasonal distribution, Tanana River.

BACKGROUND

Development of a standardized fishing methodology to index abundance of burbot, *Lota lota*, (Linnaeus), was begun in 1985. Peckham (1983, 1984, 1985) and Hallberg (1984 and 1985) indicated a commercially available baited double-throated hoop trap, 3 ft diameter by 12 ft length with 1 in square nylon mesh to be the most suitable of several gear types to employ in investigating populations of burbot in the rivers and lakes of interior Alaska.

Finding a suitable sampling method using hoop traps along with associated research to develop data correction factors for bias related to gear methodology and type, variable soak times, fishing effort and gear density, is the basis for this study. This project was conducted in conjunction with other research reported under parts A and B of the research project segment.

The relationship between stock density, abundance and catch per unit effort (CPUE) is an important method of monitoring major fish stocks. In general, CPUE is related to stock density and is proportional to abundance under conditions of standard fishing time, gear density and area inhabited by the fish stock where:

$$\frac{c}{f} = \frac{q \times N}{A} = q\ D, \text{ or:}$$

$$\frac{\text{catch}}{\text{effort}} = \frac{\text{catchability coefficient} \times \text{stock abundance}}{\text{area}} = \text{Catchability coefficient} \times \text{stock density}$$

In the above simplified formula, the components are subject to variability and therefore stock abundance based upon CPUE. The ultimate goal of this research is to describe these sources of variability and to standardize fishing methods, time and gear density such that CPUE accurately reflects burbot abundance in interior Alaskan waters.

The area of study is located in east-central Alaska between and ranges from 145° to 149° W long. and 63° to 65° N lat. The climatic conditions vary seasonally. Mid-winter temperatures average -13°F and daylight averages less than 4 hrs. Spring arrives as early as mid-April. Sub-freezing temperatures and snowfall can occur as late as early June. Summers are short with over 20 hrs of daylight and temperatures averaging 59°F. The fall season is usually over by mid-October. Ice-free periods for lakes vary with altitude and latitude and often occur between late May to October at lower altitudes or latitudes, with a breakup to freeze-up period of early July to late September for waters located at higher elevation or latitude. Ice thickness can exceed 5 ft. Rivers are generally ice-free from late May to early October with similar ice depth. During midsummer, surface water temperatures can rise to 65°F in lakes and 50°F in rivers. Secchi disk readings of 25 ft are common in the oligotrophic lakes sampled. Rivers are typically groundwater fed year round, with glacial till raising turbidities in systems fed by summer melt from nearby mountain ranges. Mean elevations vary from 390 to 2,950 ft above sea level.

The lakes selected for this study were Fielding Lake (63°10' N, 145° 41' W) a 70 ft deep, 1,325 acre lake, 2,644 ft above sea level and Harding Lake, (64°25' N, 146°50' W) a 141 ft deep, 2,470 acre lake, 715 ft above sea level. Burbot were sampled in an approximately 180 mi section of the Tanana River from the vicinity of Delta Junction (64°2'15" N, 145°44' W) downstream to Fairbanks (64°50' 45" N, 147°43'15" W).

Table 1 lists common and scientific names of all fish species mentioned in this report.

RECOMMENDATIONS

Research:

1. Bait sets of two net-nights (NN) is the best sampling unit of effort in lakes.

2. A standard bait should be used for hoop traps. Frozen herring is recommended.

Table 1. List of common names and scientific names used in this report.

Common Name	Scientific Name and Author	Abbreviation
Burbot	*Lota lota* (Linnaeus)	BB
Pacific herring	*Clupea harengus pallasi* Valenciennes	PH

3. Nets should be set and pulled at the same time of day to permit better comparisons of CPUE within and between systems.

4. Effort (number of traps set) should be allocated proportionally to depth strata in lakes. Alternatively, if stratification after sampling is feasible, lakes should be sampled (netting location) as randomly as possible. Refinement of optimum depth strata should be conducted on combined 1985 and 1986 data.

5. At least 200 2-NN sets should be made in each lake to insure that a minimum relative precision of ± 20% is attained with 90% confidence intervals (CI) about the stratified mean estimate given a mean catch of 1.0 burbot per set. The 1986 data should be used to modify the sampling level, if necessary.

6. Caution should be exercised in handling burbot captured below 60 feet. Methods of ameliorating handling effects should be developed, i.e. cooling of holding water and avoiding deep water sampling during midsummer.

7. Gear saturation levels and fishing power should be researched.

8. Spatial distribution of fish within systems should be noted, both within and between years, and correlated with habitat and depth.

9. Nets in rivers should be checked, rebaited and moved daily in a standard, pre-determined schedule.

10. Estimates of abundance should be developed and compared with CPUE for finite river sections and in lakes.

OBJECTIVES

Separate studies were conducted at Fielding Lake, at Harding Lake and on the Tanana River. The objectives were as follows:

1. To determine the feasibility of using hoop trap catch per unit of fishing effort statistics to index burbot population abundance and distribution.

2. To assess the effects of bias associated with gear selectivity, gear operation, gear type, environmental factors and biological variables upon CPUE data.

TECHNIQUES USED

Equipment and Procedures

Commercially available hoop nets of standard manufacture were selected as the major sampling gear for this study. Specifications were: 3 ft x 12 ft, knotted nylon netting; 1 in square mesh; twine size #15; seven fiberglass hoops with throats on the second and fourth hoops; finger-style (crowfoot) throats and Net-coat (asphaltic) treated. To prevent collapse, two sections of 1 in outside diameter water pipe were attached lengthwise with metal snaps to the first and seventh hoops on opposite sides of the trap. A rope was tied to the closed cod-end of the trap to secure it to either the river bank or a numbered buoy in lakes and allow retrieval. When desired, traps were baited with fish contained in perforated, resealable plastic containers placed in the cod end. Sliced frozen Pacific herring was the bait used for lake sampling, with one or two, 8-10 in fish used per trap. Herring and other incidentally-caught species were interchanged as required for bait during netting in the Tanana River.

Fielding and Harding Lakes:

In lakes, a 21 ft inboard jet boat was used as the work platform. Hoop nets and associated gear were carried on board and assembled just prior to setting. Sampling locations were predetermined and are described below. A fathometer was used to verify depth. The assembled trap, with or without bait, was lowered to the bottom and an individually numbered floating buoy was attached for identification. Set times were recorded to the nearest minute and depths to the nearest foot. After the predetermined soak time, the nets were manually lifted. Lift times were recorded to the nearest minute. All captured burbot were placed in a double-size wash tub filled with lake water. Total lengths to the nearest millimeter were recorded. Tag presence was noted or a numbered FD-67 Floy tag was inserted mid-dorsally. A fin was removed to later estimate tag loss. A subsample were weighed to the nearest gram. Most burbot were released mid-way between adjacent trap locations. Depending on the sampling scheme, the nets were rebaited or not, the captured burbot were either released or returned to the trap to estimate escape rate and handling effects, and the net was reset where required, and the set time was noted.

Tanana River:

In rivers, a 20 ft outboard-powered riverboat was used as a work platform. Netting locations were selected in the field due to fluctuating water levels and marked on 1:63,360 USGS maps. A habitat code was assigned to setting locations, corresponding to main river, side channel or backwater slough. The nets were baited, except during the experimental sampling described below, and set with the spreader tubing attached with the trap opening facing downstream. The net was tied to trees or anchors. The depth at the net location and the current flow was estimated and recorded. Subsequent sampling and fish handling procedures were as described above.

Sample Design

To assess potential sources of bias and develop a CPUE estimator in the lakes studied and the Tanana River, several variables were defined (Table 2). To define the effects of certain specific variables and their role in influencing a CPUE statistic, an experimental study was designed for Fielding Lake and the Tanana River. The sampling dates for Fielding Lake were 15-20 July, 19-28 August, and 23-27 September. Harding Lake was sampled between 23-26 July.

Fielding Lake:

Hoop netting locations for Fielding Lake in July were randomly selected from a grid overlay (Figure 1). The standard burbot CPUE data (as described earlier in this report) were collected. In addition, an experimental sampling scheme was designed emphasize specific variables (Table 3). The netting schedule and data base, as it relates to these variables, is schematically shown in Table 4.

Subsequent to the July sampling in Fielding Lake, it was decided to alter the program design and optimize netting locations and depths during August and September. Nets were generally fished between 30 and 50 ft deep in order to increase recapture rates of burbot for a population estimate (described in Part B of the research project segment).

Harding Lake:

Because of burbot mortality from gas bladder expansion that occurred during initial Fielding Lake sampling, Harding Lake was sampled with hoop nets in late July to further define and test methods to ameliorate the problem. The lake was arbitrarily divided into six, 25 ft (7.6 m) strata. Each stratum was sampled with 25 hoop nets. Handling strategies including time-delayed net retrieval and iceing holding tub water to test methods of reducing handling mortality. Additional CPUE data were also collected.

Tanana River:

The Tanana River from the mouth of the Wood River to Northway, Alaska, (approximately 320 miles) was arbitrarily divided into seven sections. Specific sampling sites within these river sections were selected in the field. Three river habitats within each section were selected for sampling: main river, side channel and backwater slough systems. Past research indicated that these types of areas are utilized by burbot during the open water period. The Tanana River was sampled between 24 June and 4 October (Table 5), as per procedures described above. Variables were selected for experimental examination (Table 6). The sample design for hoop traps and the associated data base as it relates to these variables is schematically shown in Table 7.

Table 2. Variables selected for examination to develop a standardized CPUE statistic for indexing burbot populations.

Variables	Sampling Location Fielding Lake	Harding Lake	Tanana River
Burbot abundance *	X		
Burbot density	X	X	X
Burbot distribution	X	X	X
Phototropism	X		
Gear selectivity *	X		X
Gear operation	X	X	X
Depth of set	X	X	X
Bait	X		X
Soak time	X	X	X
Escape rate	X		X
Handling mortality	X	X	X

* May not yield results from this study.

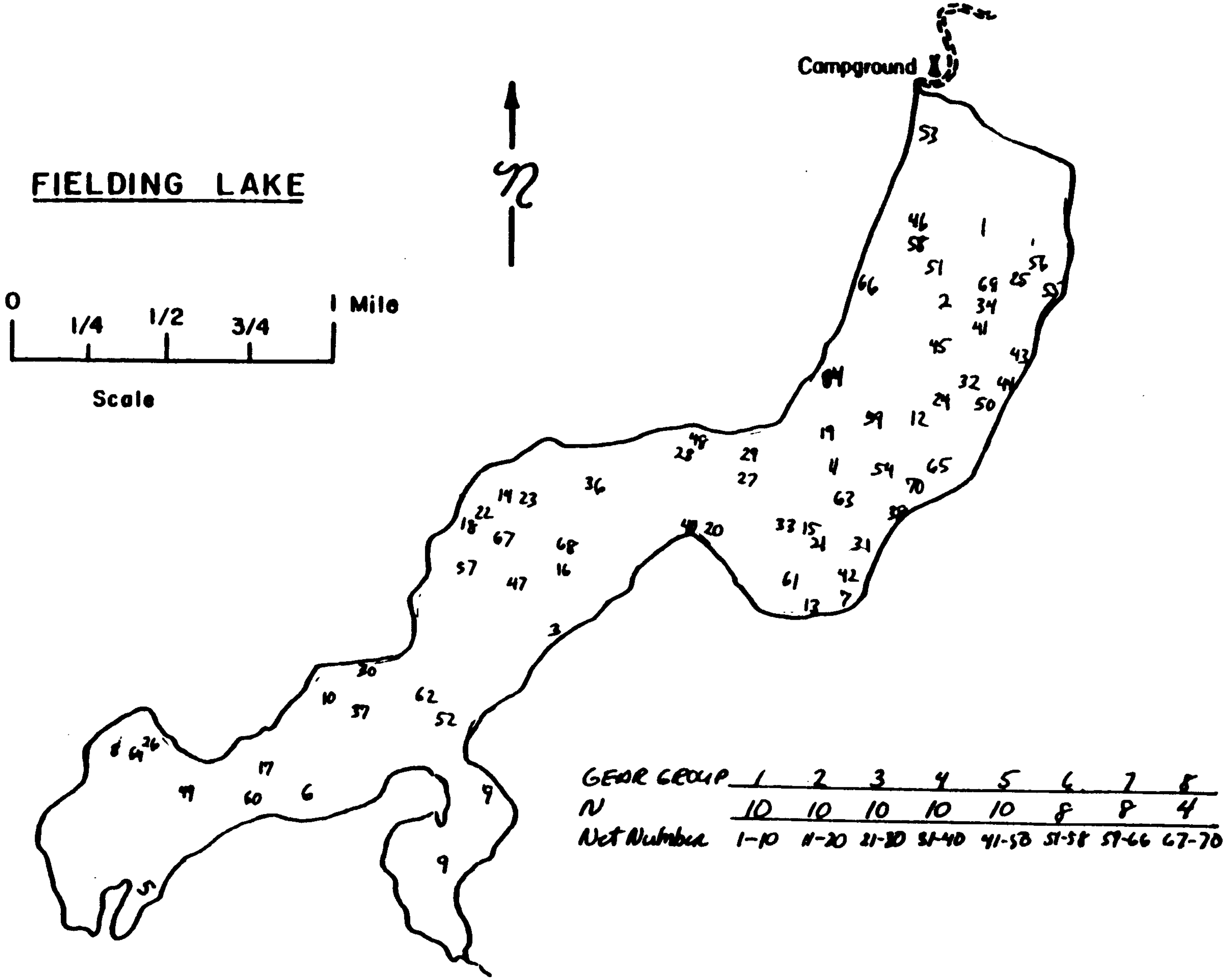

Figure 1. Random experimental hoop netting locations for Fielding Lake, 15-20 July 1985.

Table 3. Variables examined versus CPUE with the experimental netting schedule in Fielding Lake, July 1985.

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1. Phototropism
   - A. Standard 24 hour net set - evening to evening.
   - B. Dark period net set - 12 hours - evening to morning.
   - C. Light period net set - 12 hours - morning to evening.
   - D. Non-standard net set - 24 hours - morning to morning.

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2. Bait - Standard = 24 hr set
   - A. Bait fresh at each net check = standard.
   - B. Bait fresh at initial set only.
   - C. No bait used.

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3. Soak Time
   - A. Standard net set with fresh bait - 24 hour - evening to evening.
   - B. Two day net set - baited once only.
   - C. Three day net site - baited once only.
   - D. Four day net set - baited once only.
   - E. Five day net set - baited once only.
   - F. Twelve hour net sets - half fresh bait, half aging bait.

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4. Escape Rate and Size Selectivity
   - A. Captured burbot sampled, marked and returned to same net. Retained burbot noted in subsequent net lefts to determine escape rate.

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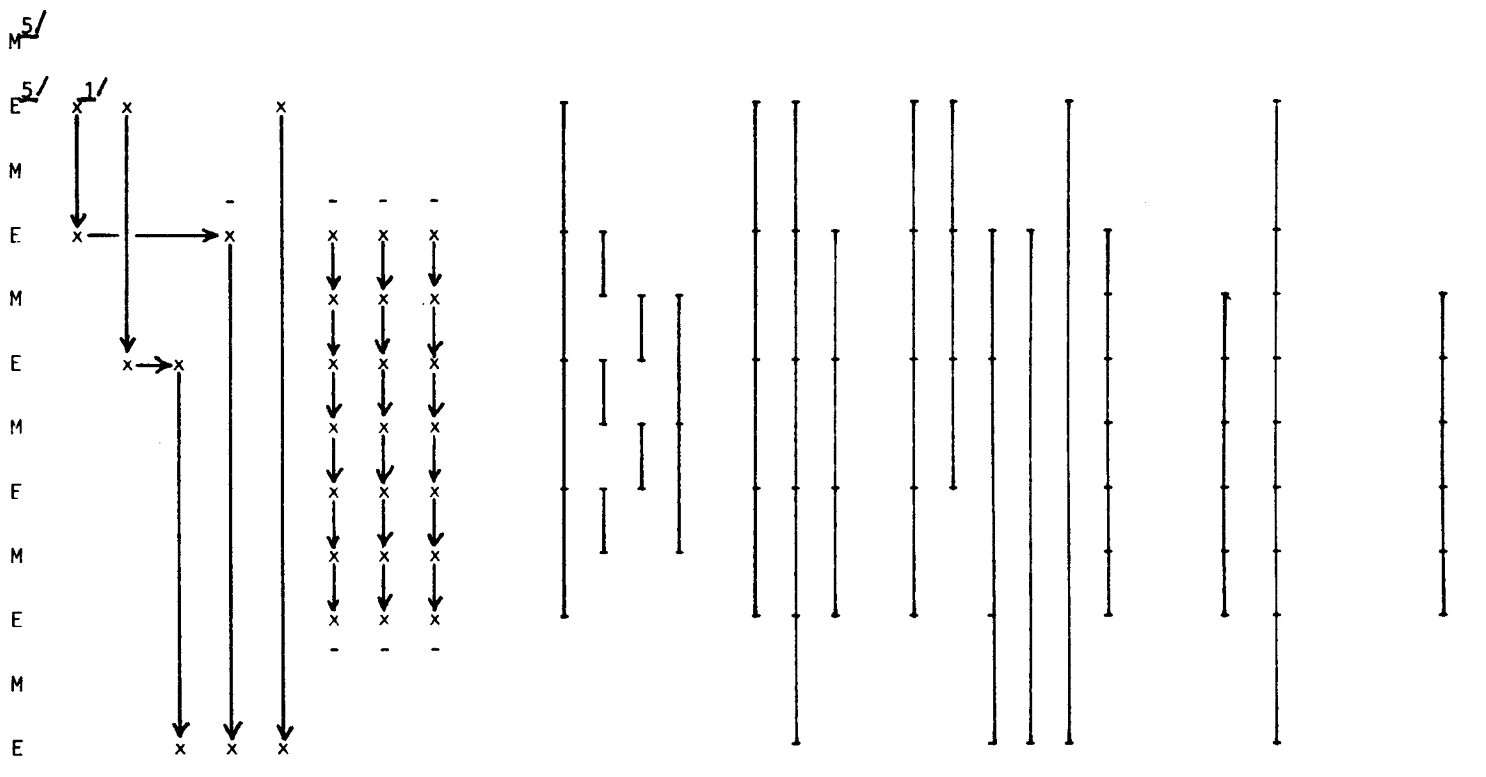
5. Handling Effects.
   - A. Mortality of burbot sampled and returned to hoop nets was noted.

Table 4. Experimental netting schedule and data base for Fielding Lake, July 1985.

Gear [2] Groups	Net Schedule 1	2	3	4	5	6 [3]	7	8 [4]
N	10	10	10	10	10	8	8	4

Day



Variables - Data Base [6]

	1 Phototropism				2 Bait			3 Soak Time						4 Escape & Selectivity		5 Handling Effects
	A	B	C	D	A	B	C	A	B	C	D	E	F	A	B	A
Gear Group:	1	6	6	6	1	2	8	1	2	3	4	5	6	6	1	6
	6	7	7	7	6	3		6	7	7			7	7	2	7
					7	4		7							3	
						5									4	
						7									5	
															6	
															7	

Note: 1. x = net check & reset
2. Groups 1,2,3,4,5,7 baited at start of experiment.
3. Group 6 baited at each check.
4. Groups 8 not baited
5. Morning/evening
6. See Table 4.

Table 5. Monthly Tanana River burbot sampling schedule by section, 1985.

Dates	Section	Area
24-28 June	4	Salcha River to Little Delta Creek
10-14 June 16-17 September	5	Little Delta Creek to Tanana Bridge at Big Delta
29 July-2 August	3	Moose Creek to Salcha River
8-12 July 5-9 August 19-20 September	6	Bridge at Big Delta to Volkmar River
12-16 August	2	Fairbanks to Moose Creek
5-9 August	7	Volkmar River to Northway
1-4 October	1	Wood River to Fairbanks

Table 6. Variables examined versus CPUE with the experimental netting schedule in the Tanana River, 1985.

1. Bait - Standard = 24 hr set and not move
   - A. Bait fresh at each net check and not move.
   - B. Bait fresh at initial set only and not move.
   - C. Bait fresh at each net check and move.

2. Soak Time
   - A. Standard net set with fresh bait - 24 hour - evening to evening.
   - B. Two day net set - baited once only.
   - C. Three day net set - baited once only.
   - D. Four day net set - baited once only.

3. Escape Rate and Size Selectivity
   - A. Captured burbot sampled, marked and returned to same net. Retained burbot noted in subsequent net lifts to determine escape rate.

4. Handling Effects.
   - A. Mortality and physical condition of sampled burbot retained in hoop traps noted.

Table 7. Experimental hoop netting schedule and data base for The Tanana River, 1985.

Gear Group N Day		Net Schedule 1/8	Net Schedule 2/8	Net Schedule 3/8	Variables - Data Base 5/: 1 Bait A	1 Bait B	1 Bait C	2 Soak Time A	2 Soak Time B	2 Soak Time C	2 Soak Time D	3 Escape & Selectivity A	3 Escape & Selectivity B	4 Handling Effects
	M		1/											
1		x	x	x	x	x	x	x	x	x	x	x	x	x
	E													
	M													
2		x	x	x	x	x	x	x				x	x	x
	E													
	M													
3		x	x	x	x	x	x	x	x			x	x	x
	E													
	M													
4		x	x	x	x	x	x	x		x		x	x	x
	E													
	M													
5														
	E	x	x	x	x	x	x	x			x	x	x	x
Gear Group:					1	2	3	1	2	2	2	1, 2	1, 2, 3	1, 2

Note: 1. x = net check & reset or moved
2. Group 1 baited daily and not moved
3. Group 2 baited once and not moved
4. Group 3 baited daily and moved
5. See Table 6

Statistical Analysis:

Statistical analyses were conducted in concert between various members of the Sport Fish staff and are described as they appear in the Findings Section.

FINDINGS

Fielding Lake

During July, August, and September of 1985, a series of experiments were conducted on Fielding Lake with the objective of determining whether hoop traps were an effective sampling gear for: (1) catching burbot; and (2) indexing their abundance.

It was decided that the following questions would be examined initially:

1. Effort expended - Effort is measured as soak time of a hoop trap. What is the best measure of effort; hours or net nights?

2. Baiting strategy - Is bait needed to catch burbot? Does a trap which is re-baited periodically catch burbot more effectively than a trap whose bait is unchanged for the duration of the set?

3. Depth of gear - Is there a relationship between depth of set and burbot catch? Should catch data be stratified and if so, what is the best stratification methodology? What is the best method of developing an abundance index?

4. Time of year - Do the relationships between depth and catch of burbot change during the time period examined?

5. Sample size - What sample size is needed to reach desired levels of precision?

6. Escape rate - Can burbot caught in hoop traps escape and if so, is the escape rate size biased?

7. Handling effects - Do burbot exhibit deleterious effects from capture in hoop traps?

Following are standard terminologies that are used throughout this report. Soak time is the elapsed time between immersion and retrival of the net. A set is a single identifiable hoop trap being immersed at a specified depth and remaining there for its entire soak time.

During a set, the catch in the trap is not emptied until the end of the soak time. A lift refers to an instance when a trap is retrieved, its catch recorded, and it is immediately immersed at its previous location without being emptied. Partial soak time is the elapsed time between two consecutive lifts.

Summary of Analyses of July Hoop Trap Data From Fielding Lake:

Question 1: What is the "best" measurement of fishing effort? The soak time of a trap was considered the unit of effort. Each effort was recorded to the nearest hundredth hour, along with set time and date and pull time and date.

Those participating in the experiment felt that sets with a soak time that included a nighttime period were more effective than sets during only daylight hours. The implication of this is that, for example, 8 hours of soak time during the day for a trap is not equivalent to 8 hours of soak time that includes one period of darkness. The following analysis examines whether daytime catches are significantly different than nighttime catches.

The data for this analysis were from 14 hoop traps fished during July that had soak times of approximately 80 hours. After these traps were set, they were lifted twice each day approximately 9-15 hours apart and the catch at that time recorded. The traps were not emptied but returned to the bottom. These data supplied two groups of observations; catches during only daylight hours (daytime lifts) and catches which had been exposed to one period of darkness (nighttime lifts). Because each trap is supplying observations for both groups, the depth distribution and baiting strategy are identical.

The mean partial soak times were 9.35 hours for daytime lifts and 14.28 hours for nighttime lifts (Table 8). Total catch for each group cannot be directly compared because approximately 35 percent more effort was expended during the nighttime lifts than the daytime lifts. To account for the difference in efforts, the CPUE (catch of burbot per hour of partial soak time) was calculated for each lift and used for comparison.

The frequency distributions of the CPUE data (Fig. 2) are very skewed. The CPUE data were tested against the normal distribution using the nonparametric Kolmogorov-Smirnov one sample test (Conover 1980). The data were found to be significantly different from the normal distribution ($P < 0.001$).

A nonparametric procedure was used to compare daytime versus nighttime lifts because the CPUE data were not normally distributed. The Mann-Whitney test (Conover 1980) was used to compare the two catch rate distributions. The assumptions for this test are: (1) the samples for each group are random samples from their respective populations and; (2) the samples within a group and among groups are independent of each other. Assumption 2 may not be met by these data if the presence of burbot caught in a trap during a previous lift interval influences the catch of later lifts. This will be discussed further in a later section.

The CPUE of daytime and nighttime lifts were significantly different ($P < 0.021$) by the Mann-Whitney test. The mean rank for the daytime lifts was less than the mean rank of the nighttime lifts. This indicates that CPUE for lifts exposed to a period of darkness is higher than CPUE of lifts exposed only to daylight hours.

Table 8. Summary statistics for daytime and nighttime lifts from 14 hoop trap sets in July 1985, in Fielding Lake.

Lift Period	Number of Lifts	Total Soaktime	Mean Soaktime	Mean Time of Set	Mean Time of Pull	Burbot Catch Frequency:				Total catch	Mean CPUE[1]
						0	1	2	3		
Daytime	42	392.6	9.35	12:11	21:32	38	4	1	0	6	0.0153
Nighttime	42	599.8	14.28	21:48	12:08	27	8	5	2	24	0.0400

[1] Mean CPUE calculated as (total catch/total effort).

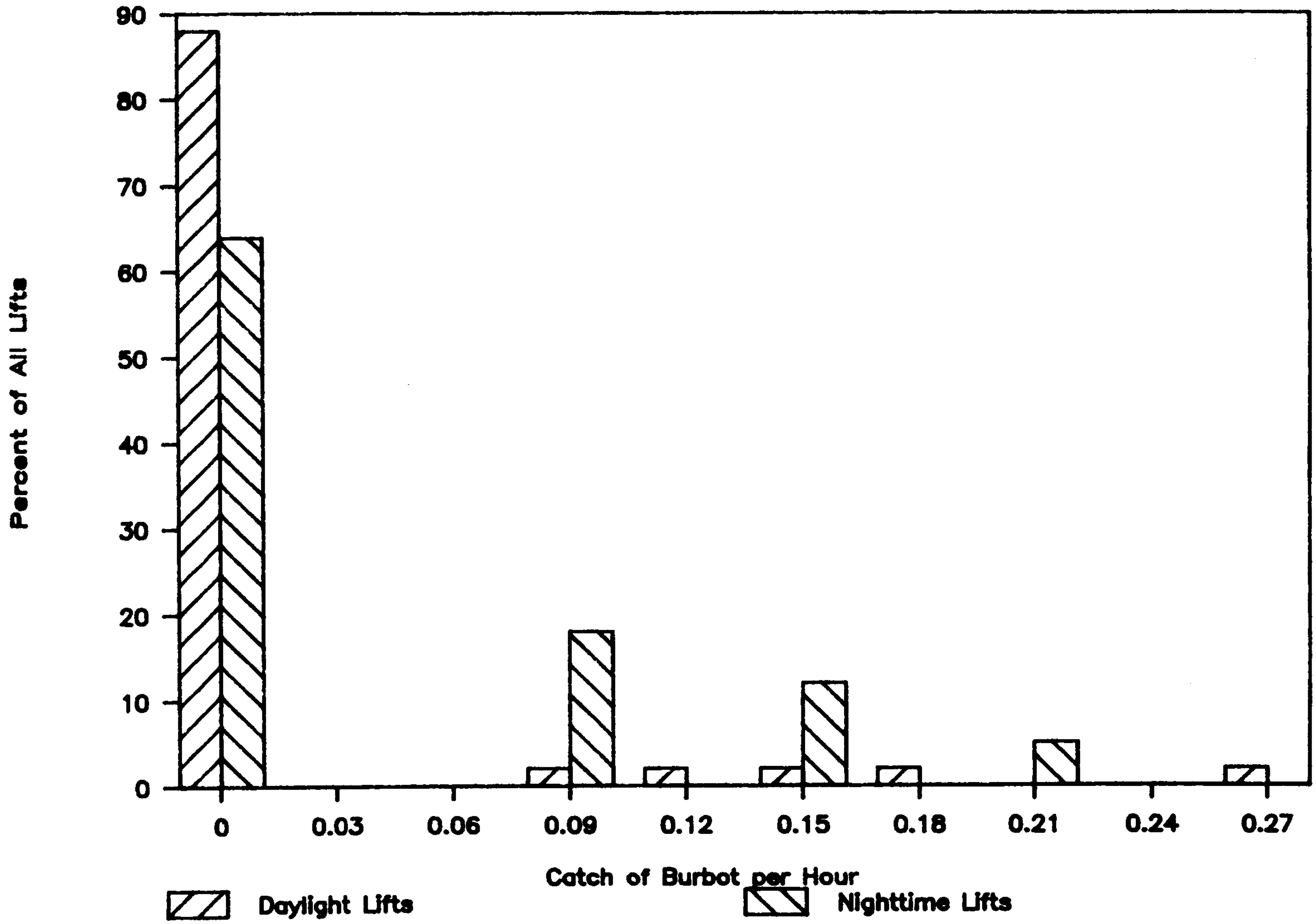


Figure 2. Frequency distributions of CPUE for daytime and nightime lifts, Fielding Lake, July 1985.

Qualitative evidence of the greater effectiveness of nighttime lifts versus daytime lifts is present in the individual catch records for each of the 14 sets (Table 9). Of the 31 burbot caught by these traps, only 6 were caught during daytime lifts.

The previous analyses indicate that there is a significant difference in the rate of catch among lifts that are soaked only during daylight hours and those that include a period of darkness during their soak time. Therefore, hours soaked is not an adequate measure of effort because there is no distinction between daytime and nighttime hours. The majority of the burbot were caught during nighttime lifts; therefore, number of net-nights (NN) soaked would be a better measure of effort than elapsed hours.

Because the traps were checked on a regular schedule during the study, the number of hours of soak time for sets with equal NN of effort are about the same (Table 10). Net-night is used as the measure of effort for all subsequent analyses.

Although lifts that included one period of darkness during their soak time were more effective at catching burbot, it cannot be concluded that this is due to a phototactic effect (i.e., burbot are more active during the night). Most of the nighttime lifts were not pulled until about noon (range 9:30-14:00), so their soak times included a number of hours of full daylight.

<u>Question 2</u>: What is the most effective baiting strategy? Three baiting strategies were examined: (1) bait was not changed during the soak time of a set (constant bait), (2) new bait was placed in the hoop trap on every lift (rebait), and (3) no bait was placed in the trap.

The 14 hoop trap sets used in the previous analysis were used to examine the effect of baiting strategy on the catch of burbot. Seven of these traps were fished with rebaiting and seven with constant bait. In addition, four traps were fished for three days with no bait. The seven rebaited and seven constant bait hoop traps were matched for depth (Table 9) so the effect of depth is the same for both groups. The four unbaited traps had depth distributions similar to the others, but were not identical.

Summary statistics for all three baiting strategies were calculated (Table 11). Only the total catch through the third daytime lift was used for this comparison. The four unbaited traps were more difficult to compare to the other baiting strategies because they were not matched as well for depth with the others and the overall sample size was smaller.

The total catches of the two baiting strategies for 3 and 4 NN were tested for differences in total burbot catch using the nonparametric Wilcoxon signed rank test. The total burbot catch of the seven rebaited and seven constant bait hoop traps when compared to each other after matching for depth of set were not significantly different (P = 1.000). The catch patterns of the two strategies however, appeared to be

Table 9. Catch of burbot by 14 hoop trap sets in Fielding Lake, July 1985.

Baiting Strategy	Depth of Set	1 N	1 D	2 N	2 D	3 N	3 D	4 N	Total Catch
Rebait at every lift.	17	0	0	0	0	0	0	0	0
	32	0	0	2	0	1	0	1	4
	58	1	0	1	0	0	1		3
	58	1	0	0	1	1	1	0	4
	15	0	0	0	0	0	0	0	0
	54	2	1	0	0	1	-		4
	42	0	0	1	0	0	0		1
Totals		4	1	4	1	3	2	1	16
Same bait for entire set.	17	0	0	0	0	0	0		0
	33	3	0	2	0	0	0	0	5
	60	0	0	1	0	0	0		1
	60	2	0	0	0	0	0	0	2
	18	0	0	0	0	0	0	0	0
	50	2	0	0	0	0	0	0	2
	42	0	2	3	0	0	0	0	5
Totals		7	2	6	0	0	0	0	15

[1] N = Nighttime lift, D = daytime lift, and the number indicates the sequence of the lifts. Recorded catches are the number of burbot caught during the indicated lift interval.

Table 10. Hours of soak time for hoop traps fished in Fielding Lake in 1985.

Net-Nights of Effort		July	August	September
1 NN	mean	22.9	23.7	18.7
	SD	2.02	2.63	1.71
	range	10.8 - 28.1	17.5 - 29.8	17.9 - 21.7
	SS	34	156	5
2 NN	mean	42.8	41.5	44.2
	SD	1.55	1.85	1.18
	range	40.5 - 45.6	39.5 - 43.8	43.1 - 47.9
	SS	10	42	32
3 NN	mean	71.5	75.0	68.9
	SD	1.62	0.77	1.63
	range	68.4 - 73.6	72.6 - 75.6	66.1 - 70.2
	SS	10	21	5
4 NN	mean	93.2	97.4	87.6
	SD	1.22	0.18	0.04
	range	90.5 - 94.6	97.1 - 97.8	87.6 - 87.7
	SS	10	29	2
5 NN	mean	114.0		
	SD	0.37		
	range	113.2 - 114.5		

NN = Net nights of soak time.

Table 11. Summary statistics for rebaited, constant bait, and no bait hoop trap sets made in Fielding Lake, July 1985.[1]

Bait Strategy	Total NN Fished	Total Soaktime[2]	Mean Soaktime[2]	Total Catch	Mean CPUE[3]
Rebaiting	21	475	68	15	0.71
Constant Bait	21	478	68	15	0.71
No Bait	12	272	68	1	0.08

1 All traps set on 16 July and data summarized through 19 July.

2 Soak time in hours.

3 Mean CPUE calculated as (total catch/total NN fished).

different (Table 9). The total catch by lift period is evenly distributed among each of the first three days (nighttime lift and daytime lift combined) of soak time for the rebaited traps. In comparison, the entire catch for the constant bait traps occurred during the first three lift periods.

Because the entire catch of the constant bait hoop traps occurred during the first two NN, the total catch at that time was compared to the total catch after two NN for the rebaited traps. The same non-parametric procedure described above was used to test for differences in total catch. No significant difference was found.

The four unbaited hoop traps caught only one burbot in 272 hours of total soak time. The mean catch per net-night of the rebaited traps and constant bait traps was almost nine times greater than that of the unbaited traps (0.71 as compared to 0.08; Table 11).

There was no difference in total burbot catch between the rebaiting and constant bait strategies for sets with two to four day soak times, however there is a difference in the pattern of the catch between the two strategies for the 14 sets examined. Rebaited traps caught burbot at a relatively constant rate during the first three days of soak time. The entire catch of the constant bait traps was taken during the first two NN. This may be due to the attractive power of the bait "scent" expiring after about 40 hours. Baited traps were much more effective for catching burbot than non-baited traps, as might be expected. Considering catch rates and gear handling required, we concluded that the best fishing strategy is to bait traps at the start of the set only.

The data analyzed for the next series of questions were obtained from 60 hoop trap sets from the July fishing period with soak times of one to five NN and a constant baiting strategy (Table 12). These traps were not lifted during their soak time. The data consist of 10 traps set for one NN, 10 traps set for two NN, 10 traps set for three NN, 10 traps set for four NN, and 10 traps set for five NN. Ten additional one-NN sets were made at the same locations as the first 10 traps. Two hypotheses about this data set were tested before more detailed analyses were conducted.

Hypothesis 1. The depth distribution for the sets in an effort group (1-NN, 2-NN, etc.) are equal (this is expected because traps were randomly located).

The distribution of the depths of the 60 sets appeared to be non-normal (Fig. 3). The nonparametric Kruskal-Wallis (K-W) test (Conover 1980) was used to compare the depth distributions of the different effort groups. The null hypothesis for the K-W test is that the depth distributions of the groups being compared are identical. The test is designed to be sensitive to differences among means of the groups so the alternative hypothesis is that the populations do not have identical means. The major assumptions for this test are that the samples are drawn randomly and there is mutual independence between samples.

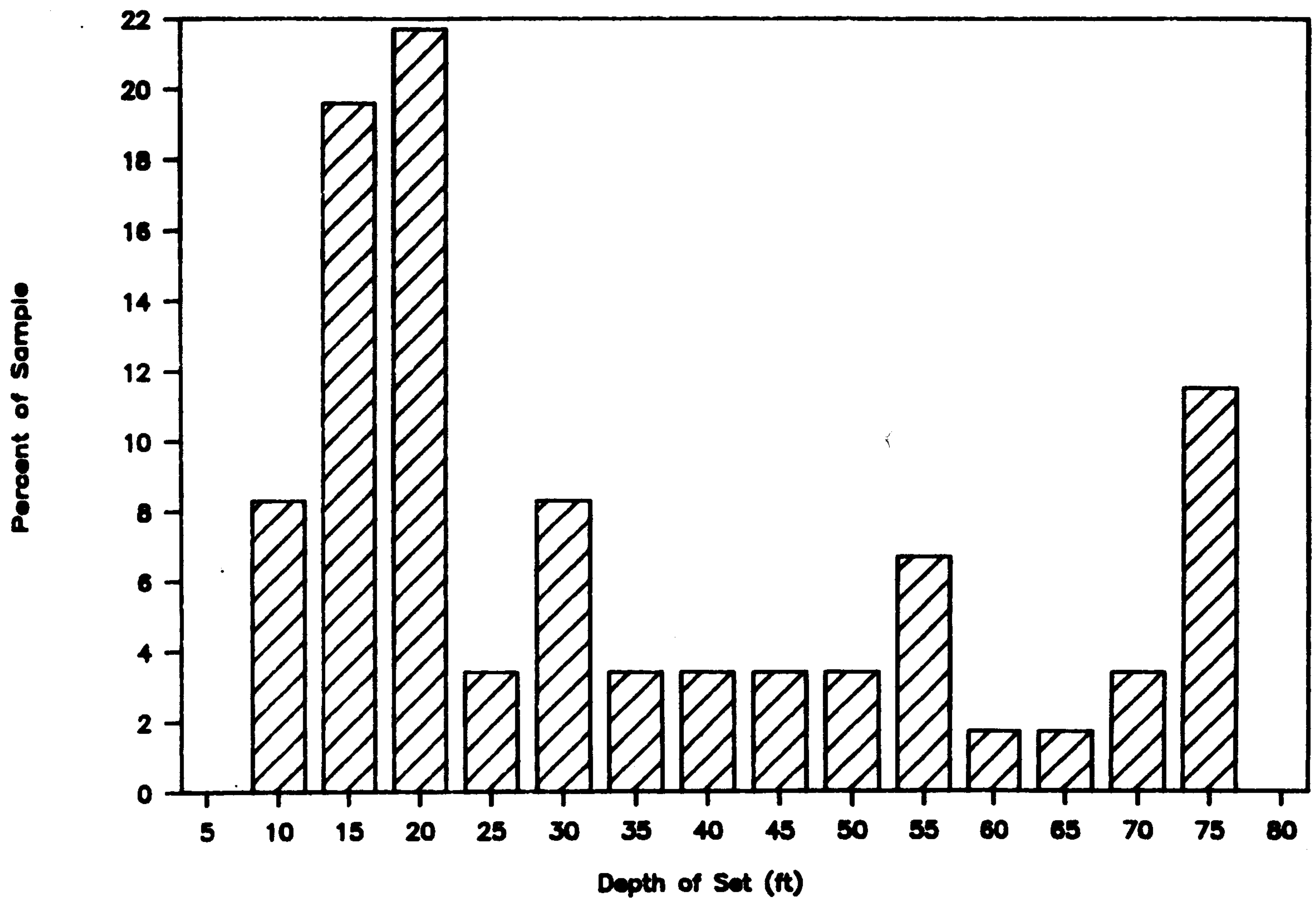


Figure 3. Depth distribution of 60 hoop trap sets made in Fielding Lake, July 1985.

Table 12. Total catch of burbot and depth of set for the constant bait hoop traps set in Fielding Lake, July 1985.

Number	Net-Nights of Soak Time					
	1	1[a]	2	3	4	5
1	0 (7)[b]	0	0 (10)	0 (12)	1 (12)	1 (12)
2	0 (10)	0	0 (17)	1 (20)	0 (14)	0 (17)
3	1 (12)	0	2 (17)	3 (20)	2 (20)	3 (17)
4	0 (14)	0	0 (19)	1 (28)	2 (21)	1 (20)
5	2 (14)	0	5 (33)	2 (30)	3 (23)	2 (33)
6	1 (15)	0	1 (40)	6 (30)	1 (26)	3 (42)
7	0 (17)	1	4 (40)	6 (43)	6 (50)	
8	0 (18)	2	11 (50)	3 (53)	2 (57)	13 (52)
9	4 (72)	1	8 (55)	3 (55)	3 (63)	2 (73)
10	2 (75)	0	2 (70)	3 (70)	3 (72)	5 (75)
Totals	10	4	33	28	19	36

[a] Replicate of first 1 NN sets, same depth of sets.

[b] Depth of set in feet in parentheses.

The depth distributions of the sets in each effort group were significantly different ($P< 0.084$). The mean rank for the 1-NN group (21.5) was very different from the mean ranks of the other groups (range 33.6 to 36.4). Therefore, the 1-NN group was removed and the K-W procedure was conducted again. There was no significant difference ($P > 0.952$) among the depth distributions of the 2, 3, 4, and 5 NN effort groups. The range of the mean ranks of these effort groups was 19.5 to 21.7. Despite the randomized design, the 1-NN sets tended to be placed in shallower depths than the other sets. Therefore, any effect of depth is removed when the total catches of burbot for the 2 to 5 NN sets are compared.

Hypothesis 2. If all other factors are similar (depth of set, etc.), there are no differences among the total burbot catches of constant bait sets of 2-NN, 3-NN, 4-NN, and 5-NN. This hypothesis was formulated based on the earlier analysis of seven constant bait traps where no burbot were caught after two NN of effort.

The distributions of the catch of burbot per set for the 2-NN, 3-NN, 4-NN, and 5-NN effort groups were compared using the Kruskal-Wallis test. There was no significant difference ($P> 0.779$) among the distributions of burbot catch (or alternatively the mean catch of burbot) for the 2-, 3-, 4- and 5- NN effort groups. The mean ranks of these effort groups ranged from 17.7 to 22.3. The result of this analysis supports the more qualitative evidence discussed earlier in that, for constant bait traps, nearly all burbot were caught during the first two NN of effort. Therefore, for these data, the catch of burbot by 2-, 3-, 4-, and 5- NN sets can be pooled and used to examine the effect of depth on catch.

Question 3a: Does depth of set effect the catch of burbot?

The 40 hoop trap sets from the previous analysis (10 sets each with soak times of 2 to 5 NN) were analyzed to determine if depth was a significant factor. The 40 sets were placed into three arbitrarily chosen depth groups, 1 - 20 ft (ss = 14), 21 - 40 ft (ss = 11), and greater than 40 ft (ss = 15). The distributions of burbot catches among the three depth groups were compared using the K-W test. The burbot catches by depth groups were significantly different ($P< .001$). The means ranks were 10.8, 21.0, and 29.2 for the 1-20 ft, 21-40 ft, and > 40 ft depth intervals, respectively.

Depth of set had a significant effect on the catch of burbot. In July, shallower sets (< 20') caught fewer burbot than deeper sets (> 20'). If some measure of burbot catch is to be used as an index of abundance, depth of set must be considered as a variable. One method of doing this is to stratify the index estimates by depth category.

Question 3b: What stratification scheme should be used for depth?

A nonparametric method of determining the "best" depth stratification was desired because of the non-normal nature of the data. The "best" depth stratification scheme would be one that maximized the differences in mean burbot catch per set among the depth categories. Translated to a nonparametric procedure, the goal was to select a stratification scheme that maximized the differences among the mean rank of the catches for each depth category. The measure of difference among categories was the chi-square approximation for the Kruskal-Wallis statistic. Five depth stratifications schemes were examined using the 40 hoop trap catches. Beginning at a depth of one foot, depths were stratified by 10 ft intervals, 15 ft intervals, 20 ft intervals, 25 ft intervals, and 30 ft intervals.

Stratification by intervals of 10 ft produced the maximum among group differences (Figure 4). This stratification scheme was simplified because very few sets occurred in depths less than 10 ft and greater than 70 ft in Fielding Lake. Depths between 1 and 20 ft were considered as a single category as were depths greater than 60 ft. With this modification, the chi-square value for the stratification still exceeded the others and was chosen as the best method of stratification. Consequently, for initial analyses, depth was categorized into six strata: (1) 1' - 20', (2) 21' - 30', (3) 31' - 40', (4) 41' - 50', (5) 51' - 60', and (6) > 60'.

Comparisons between 1 NN sets and multiple NN sets were difficult because 1 NN sets had a depth distribution that was significantly shallower than sets with 2 or more NN. It is important that the relationships between burbot catch and depth for 1-NN sets and between 1-NN sets and sets greater than 1-NN be determined. One source of additional data for 1-NN sets are the 14 experimental traps (seven constant bait and seven rebaited traps) used in the examination of baiting strategy. These traps can be considered as 1-NN sets by using the recorded catch at the second lift interval. These traps were fished with very similar strategies as the 20 one NN sets except for a wider distribution by depth. The mean soak time of the experimental sets on the second lift was 22.9 hours compared to a mean soak time of 23.0 hours for the one NN traps. To include these 14 sets with the other 1-NN sets, the following were assumed: (1) the one lift during their soak time did not affect the catch of burbot, and (2) for the rebaited traps, changing the bait after about 15 hours did not affect the catch during the remaining 8 hours of time considered as 1 NN.

Analyses as described previously for the original 60 sets were re-done with the 14 additional 1-NN sets added to the data bringing the total data to 74 samples (40 sets from 2-5 NN and 34 sets of 1 NN). Hypothesis 1 (the depth distribution of the sets in each 1 to 5 NN effort groups are equal) was again tested with the 74 data points.

There was no significant difference ($P > 0.592$) among the depth distributions of the sets in the 1 to 5 NN effort groups and hence the burbot catches for each effort group can be compared with no adjustment for depth. Hypothesis 2 (there is no difference between the catch of burbot by 1 to 5 NN effort groups) was again tested with the full 74 data points. The catches of burbot by effort group were significantly different ($P < 0.001$). Based on the previous analysis, which found no difference in catch by effort group for 2 - 5 NN effort groups, it was concluded that there is a significant difference between the catch of

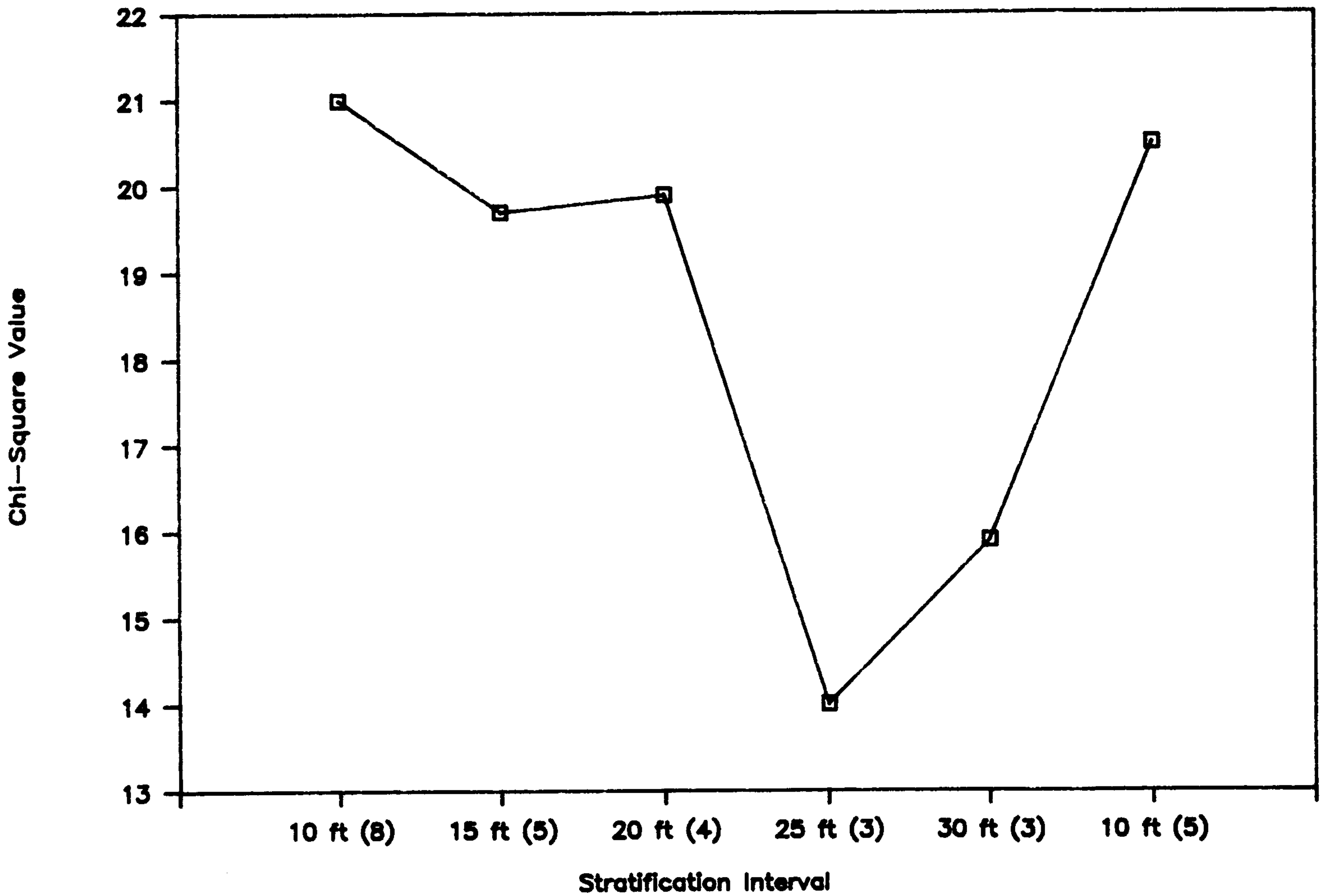


Figure 4. Chi-square value for Kruskal-Wallis test of burbot catch per set among different depth strata for five different stratification schemes. Number in parentheses is the number of strata for the stratification.

burbot by 1-NN sets and all 2 NN and greater sets. Therefore, 1-NN sets must be considered separately from the others. Because they need to be considered separately, it was decided to determine what depth stratification scheme is best for 1-NN sets. The same statistical procedure as earlier described was used to determine the "best" depth stratification for the 2-5 NN sets. Stratification by 10 ft depth intervals maximized differences among groups. Depths between 1 and 20 feet were combined as the first depth interval and depths greater than 60 feet as the last interval, as was done previously. Again, the same depth stratification scheme as for 2 and greater NN sets was the "best" for the 1-NN sets.

Question 3c: What is the best method of developing an abundance index:

For nearly all the previous nonparametric analyses (examining baiting strategies, net-nights of effort, and depth), the basis of comparison has been the distribution of the total catch of burbot per hoop trap set in the groups being compared. For most of the analyses, the tests were based on the mean rank of the catches in a group. From these analyses the following conclusions were developed:

1. The optimal depth strata for Fielding Lake hoop trap catch data was: 1-20', 21-30', 31-40', 41-50', 51-60', and greater than 60'.

2. Depth of set being equal, the total catch of burbot by constant bait sets of 2 - 5 NN are not significantly different. There is a significant difference between the catch of sets of 1 NN and 2 or more NN, however.

The mean catch of burbot per trap for 1 NN sets and 2 - 5 NN sets by depth interval was calculated. The mean catch per set of the 2-5 NN sets ranged from 1.71 to 4.14 times greater than the 1-NN sets (Table 13). The relative frequency of burbot catch for sets of 1 NN and 2 or more NN was calculated. The one net-night sets had a much higher frequency of zero catches than the 2-5 NN sets, as might be expected (Figure 5). Although neither frequency distribution is normal, the one net-night sets are much more skewed than the other group.

One objective of this study was to determine if an effective index of burbot abundance could be estimated from the hoop trap data. Usually a single index value is desired which would require some method of combining the 1-NN and 2-5 NN groups. Based on limited sample sizes from July, the relationship between catch per set of 1 NN and 2-5 NN sets varies considerably between depth strata. There is not sufficient data to adequately define this relationship from the July data.

Another problem in deriving an appropriate index value for burbot abundance is the non-normal distribution of the data. The distribution of catches for the 1-NN sets is highly skewed to the right due to the frequency of zero catches. The 2-5 NN data do not have a highly skewed distribution (Fig. 5). Combining these two data sets with normal parametric procedures would not be appropriate because of the obvious differences in distribution functions. The distribution of catch per

Table 13. Catch of burbot per set by depth interval for sets with soak times of 1 NN and sets greater than 1 NN during July 1985 in Fielding Lake.

Depth	1 Net-Night				2-5 Net-Nights				Rel.
Interval	Mean	SD[1]	CV[2]	SS[3]	Mean	SD[1]	CV[2]	SS[3]	Effic.[4]
1 - 20 ft	0.35	0.671	1.92	20	1.00	1.109	1.11	14	2.86
21 - 30 ft					2.43	1.718	0.71	7	
31 - 40 ft	1.00	1.732	1.73	3	3.00	1.826	0.61	4	3.00
41 - 50 ft	2.00	0.0		2	6.50	3.317	0.51	4	3.25
51 - 60 ft	1.40	1.140	0.81	5	5.80	4.658	0.80	5	4.14
60 ft	1.75	1.708	0.98	4	3.00	1.095	0.37	6	1.71

[1] Standard deviation

[2] Coefficient of variation.

[3] Sample size.

[4] Relative efficiency = (2.5 NN)/(1 NN).

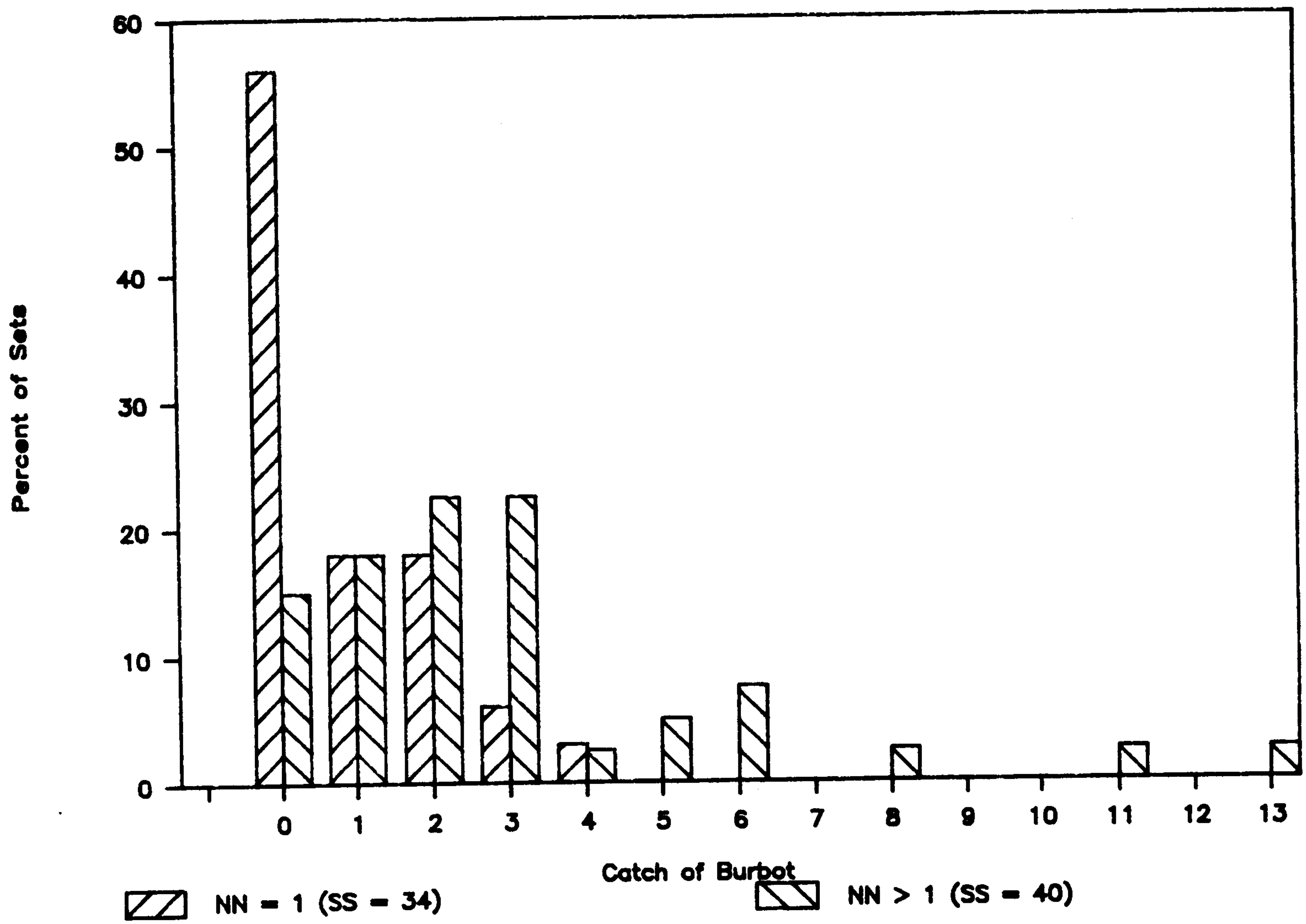


Figure 5. Frequency of catch per set of burbot for one NN sets and 2-5 NN sets in Fielding Lake, July 1985.

set for each group was compared to the Poisson distribution with the Kolmogorov-Smirnov test. Neither was significantly different from the Poisson distribution ($P > 0.712$ for 1-NN sets and $P > 0.714$ for 2-5 NN sets). The usual normal transformation for a Poisson distribution (Zar 1974) did not, however, normalize the distribution of the data ($P < 0.010$ for both groups).

The mean catch per set of traps with soak times of 2-5 NN is probably the best index for the July data in that it is less skewed. The mean catch per set for this group can be estimated using stratified sampling methods (Sukhatme et al. 1984) to combine mean catch per set by depth interval. The estimate of the population mean is;

$$Y_{ST} = W_i \, y_i,$$

where W_i is the proportion of Fielding Lake in depth interval i (assumed to be measured without error) and y_i is the mean catch per set for stratum i. Because the data were stratified by depth after the data collection period, the correct estimator for the variance of the population mean is that for post-stratification (Sukhatme et al. 1984). The approximation for the variance estimate is (with no finite population correction factor);

$$V(Y_{ST}) = (1/n) \; W_i \, s_i^2 \; + (1/n^2) \; (1 - Wi) \; s_i 2,$$

where, n = the total number of samples (over all strata), and

s_i^2 = the estimated variance of CPUE stratum i.

In July, the estimated mean catch of burbot per set was 2.390 for the 2-5 NN effort group and 0.649 for the 1-NN effort group (Table 14).

Summary of Analysis of August Hoop Trap Data from Fielding Lake:

There were 248 hoop trap sets made in August of which 156 were 1-NN sets, 42 were 2-NN sets, 21 were 3-NN sets, and 29 were 4-NN sets. Gear was distributed in the lake in a non-random manner in an attempt to maximize catch (due to objectives under Part B of the overall progress report).

A similar sequence of analyses as earlier described were performed on the August data. For these analyses the assumptions are, (1) there were no differences between the total catch of burbot by sets with 2-NN, 3-NN, and 4-NN of soak time (for a given depth) and (2) 1-NN sets need to be analyzed separately from 2 to 4 NN sets. The sequence of analysis was;

1. Determine the best depth stratification scheme using the method of analysis described for the July data.

2. Test the distribution of the catches per set for each effort group (1-NN and 2-4 NN) against the normal and Poisson distributions.

3. Estimate the mean catch per set for each depth interval in each effort group.

Table 14. Stratified estimates of mean catch of burbot per hoop trap set for 1 NN and 2-5 NN effort groups for Fielding Lake, by month, 1985.

	One Net-Night Sets					Two to Five Net-Night Sets				
Month	Mean Catch	SD[1]	95.0% CI	Coef. Variation	SS[2]	Mean Catch	SD[1]	95.0% CI	Coef. Variation	SS[2]
July	0.649	0.175	0.305 - 0.992	0.270	34	2.390	0.350	1.703 - 3.076	0.146	40
August	0.833	0.236	0.370 - 1.296	0.283	156	1.576	0.236	1.113 - 2.040	0.150	92
September						2.575	0.462	1.668 - 3.481	0.179	39

[1] Standard deviation.

[2] Sample size.

4. Estimate the mean and variance of the catch per set for each effort group using the stratified sample estimators as earlier described.

The only variation from previous analysis was that the variance approximation for post-stratified sampling could not be applied to the August and September data because they were not based on a random sampling design. Therefore, the variances were estimated with the standard variance formula for stratified sampling (no finite population correction):

$$V(Y_{ST}) = W_i^2 (s_i^2/n_i).$$

Note that the standard stratified variance formula underestimates the variance for the mean catch per set of a post-stratified design.

Because the details statistical methodology for each of these analyses have been given previously, only the results and conclusions will be presented. Stratification by 10 ft intervals maximized the between group differences for the 2-4 NN effort group. Fifteen foot intervals maximized differences between groups for the 1-NN effort group. Stratification by 10 ft intervals resulted in the second highest chi-square value for the 1 NN data. Stratification by the depth intervals selected for July gives chi-square values identical to those with stratification by 10 ft intervals for both effort groups and hence it was concluded that the July stratification scheme was appropriate for the August data.

The frequency distributions of catch per set of burbot were calculated for each effort group (Figure 6). One NN sets are skewed right and have a distribution very similar to the 1-NN sets in July. The distribution of the 2-4 NN effort group is skewed right also, but not to the degree of the 1-NN sets. One NN sets have a distribution significantly different from the Poisson distribution ($P < 0.005$). The distribution of the 2-4 NN effort group is not significantly different from the Poisson ($P > 0.143$). Transformation of either data set did not normalize the distribution of the data.

The mean catches of burbot per depth interval for 1-NN and 2-4 NN sets in August were calculated (Table 15). The mean catch per set of the 2-4 NN sets ranged from 1.24 to 3.01 times greater than the 1-NN sets. The relative efficiency (mean catch of burbot per set of 2-4 NN sets divided by mean catch per set of 1 NN sets) of 1-NN sets compared to 2-4 NN sets changed by depth interval. In August, the estimated mean catch of burbot per set was 1.576 for the 2-4 NN effort group and 0.833 for the 1-NN effort group (Table 14).

Summary of Analysis of September Hoop Trap Data for Fielding Lake:

There were 44 hoop trap sets made in September of which 5 were 1-NN sets, 32 were 2-NN sets, 5 were 3-NN sets, and 2 were 4-NN sets. Gear was distributed in the lake in a non-random manner in an attempt to maximize catch. The data were sufficient only to analyze the 2-4 NN effort group.

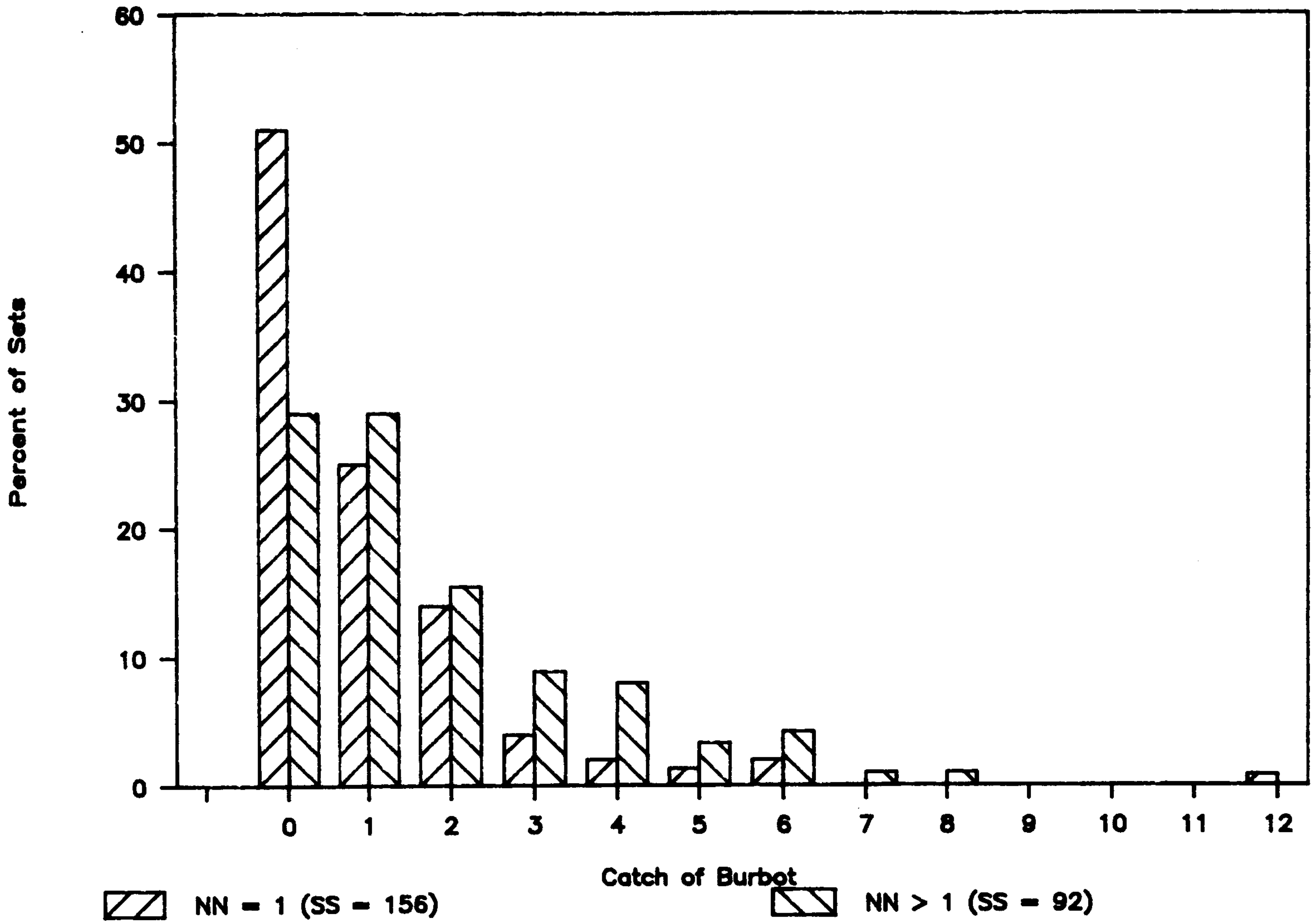


Figure 6. Frequency of catch per set of burbot for one NN sets and 2-4 NN sets in Fielding Lake, August 1985.

Table 15. Catch of burbot per set by depth interval for sets with soak times of 1 NN and sets greater than 1 NN in Fielding Lake during August 1985.

Depth	1 Net-Night				2-4 Net-Nights				Rel.
Interval	Mean	SD[1]	CV[2]	SS[3]	Mean	SD[1]	CV[2]	SS[3]	Effic.[4]
1 - 20 ft	0.85	1.676	1.97	13	1.69	1.778	1.05	16	1.99
21 - 30 ft	1.34	1.942	1.45	71	1.67	1.883	1.13	45	1.24
31 - 40 ft	0.74	0.929	1.26	46	2.23	2.159	0.97	22	3.01
41 - 50 ft	0.73	1.280	1.75	15	1.50	0.837	0.56	6	2.05
51 - 60 ft	0.25	0.463	1.a5	8	0.33	0.577	1.75	3	1.32
60 ft	0.0	0.0		3				0	

1 Standard deviation

2 Coefficient of variation.

3 Sample size

4 Relative efficiency = (2-4 NN)/(1 NN).

Stratification by 15 ft intervals maximized the between group differences for the *2-4* NN effort group. Stratification by 10 ft intervals resulted in the second highest chi-square value. Stratification by the depth intervals selected for July gives chi-square values identical to those with stratification by 10 ft intervals and hence, it was concluded that the July stratification scheme was appropriate for the September data as well.

The frequency distributions of catch per set of burbot were calculated for each effort group (Figure 7). The distribution for the *2-4* NN effort group is skewed right. The 2-4 NN sets have a distribution significantly different from the Poisson distribution ($P < 0.030$) and hence the data are not normally distributed. The mean catches of burbot per depth interval for *2-4* NN sets in September were calculated (Table 16). In September, the estimated mean catch of burbot per set was 2.575 for the *2-4* NN effort group (Table *14).*

<u>Question *4*</u>: Do the relationships between depth and catch of burbot change during the time period examined?

The Fielding Lake burbot population can be considered to be closed between July and September with mortality and recruitment negligible. Therefore, similar index values for each month would be expected. This was not the case (Table *14).* The index for 2-5 NN sets in August was significantly different ($P < 0.05$) than the July and September indices. The July and September indices were not significantly different.

The difference in monthly indices may be related to sample sizes. More than twice as many *2-5* NN sets were made to estimate the August index (*92* sets) than were made for the July (*40* sets) and September (**39** sets) indices. The July and September indices were made with nearlv identical levels of effort.

The frequency of 2-5 NN sets with catches of no burbot by depth strata and sets which caught at least one burbot by depth strata were calculated (Figure 8). In July, all zero catches occurred in the 1-20 ft depth interval. The 21-30 ft interval had the highest frequency of zero catches in August, and in September the zero catches were fairly evenly distributed throughout all strata.

<u>Question 5</u>: What sample size is needed to reach desired levels of precision?

Approximation of the number of samples needed to estimate the mean burbot catch per set for specified levels of precision were derived from the Fielding Lake data (Table 17). The sample size recommendations are intended for a stratified (by depth) sampling program with strata variances similar to those observed in the experiments. All estimates are based upon the 2-5 NN data. The number of samples required to achieve specific levels of relative precision depends upon: (1) the stratified estimate of mean catch of burbot per set, (2) the variance of the estimates in the strata, (3) the relative precision desired, and *(4)* the confidence limits to be used.

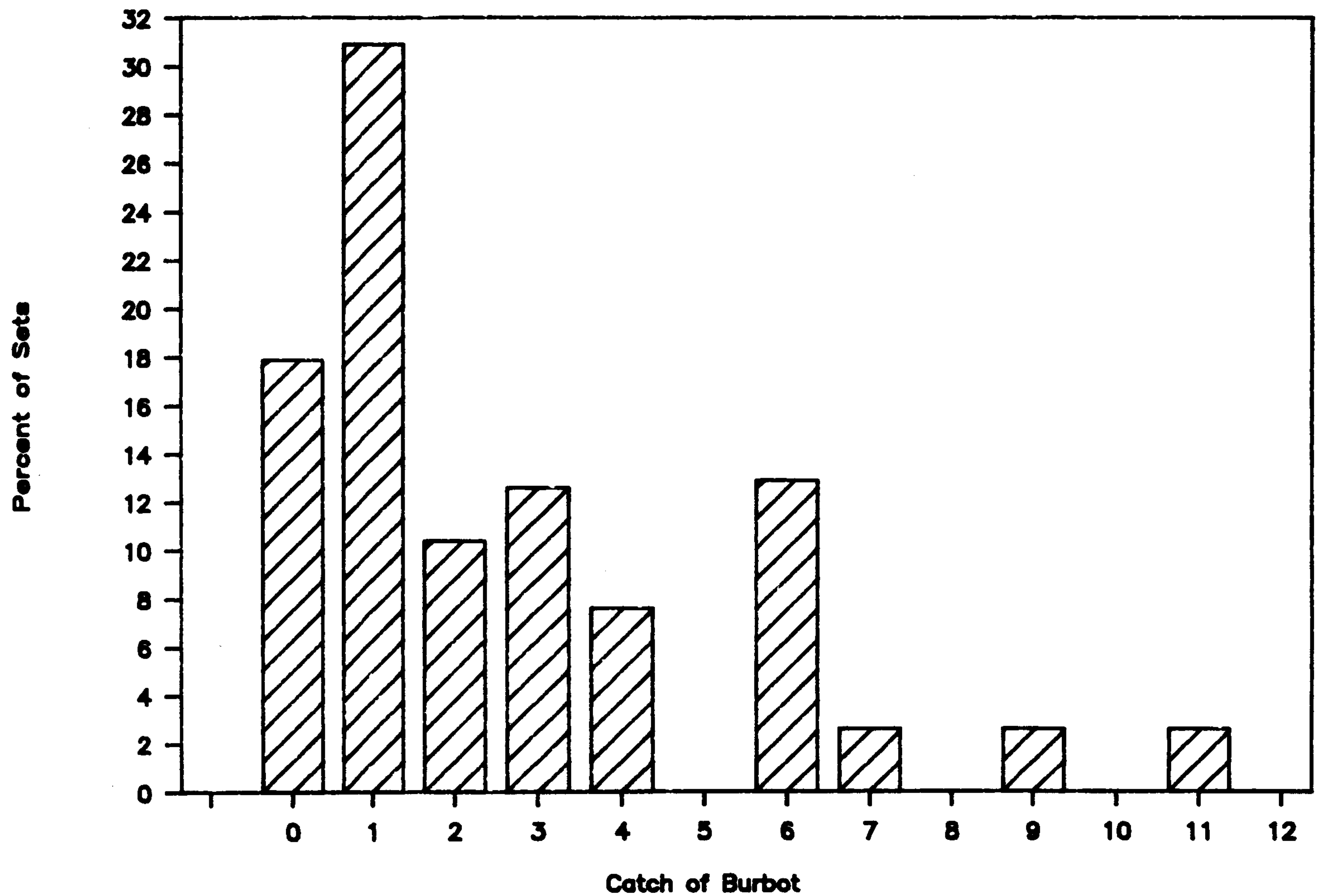


Figure 7. Frequency of catch per set of burbot for 2-4 NN sets in Fielding Lake, September 1985.

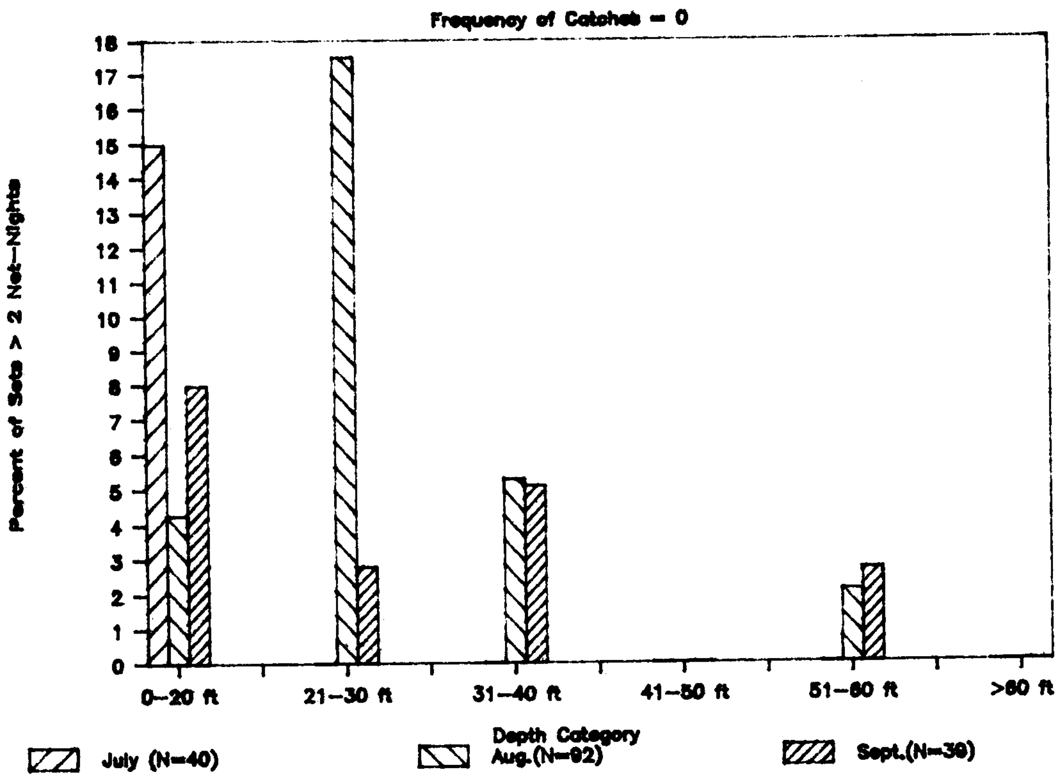
Table 16. Catch of burbot per set by depth interval for sets with soak times greater than I NN in Fielding Lake in September 1985.

Depth Interval	2-4 Kct-Nights Mean	SD[1]	CV[2]	SS[3]
1 - 20 ft	1.93	1.200	1.14	14
21 - 30 ft	3.50	4.230	1.21	6
31 - 40 ft	2.20	1.930	0.88	10
41 - 50 ft	3.60	3.130	0.87	5
51 - 60 ft	2.00	2.828	1.41	2
> 60 ft	6.00	0.0		2

[1] Standard deviation

[2] Coefficient of variation

[3] Sample size



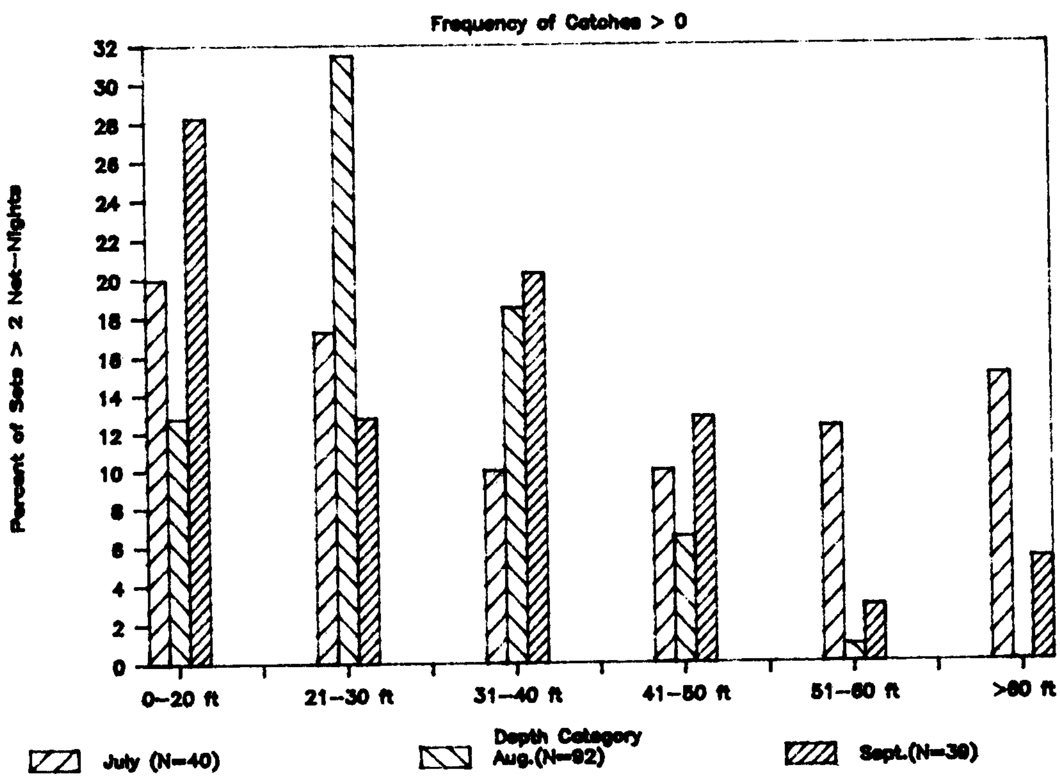


Figure 8. Frequency of 2-5 NN sets with burbot catches of zero and greater than zero for each depth interval, Fielding Lake, 1985.

Table 17. Estimated sample sizes required to achieve specified levels of relative precision for different mean index values and 90.0% and 95% confidence intervals.

Relative Precision	Mean Index[1] 1.0	Mean Index 1.5	Mean index 2.0	Mean Index 2.5
For 90.0% Confidence intervals:				
0.05	3,129 - 4,300	1,391 - 1,911	782 - 1,075	501 - 688
0.10	782 - 1,075	348 - 478	196 - 269	125 - 172
0.15	348 - 478	155 - 212	87 - 119	56 - 76
0.20	196 - 269	87 - 119	49 - 67	37 - 43
For 95.0% Confidence Intervals:				
0.05	4,443 - 6,105	1,974 - 2,713	1,111 - 1,526	711 - 977
0.10	1,111 - 1,526	494 - 678	278 - 382	178 - 244
0.15	494 - 678	219 - 301	123 - 170	79 - 109
0.20	278 - 382	123 - 170	69 - 95	44 - 61

[1] Mean burbot catch per set for 2-5 FIN data.

The sample size recommendations are intended to be used in situations where fishing effort is allocated proportional to the area of the lake within each depth interval. Proportional allocation was selected because the variances estimated for each strata fluctuated considerably within the Fielding Take data (July to September). The total number of samples (n) required to achieve a given level of precision for proportional allocation was estimated by (omitting finite population correction factor):

$$n = (W_i s_i^2)/V_o,$$

where W_i and s_i^2 are defined previously and V_o is the variance needed to establish a confidence interval with the desired level of precision. Because the strata variances in Fielding Lake change 4 over time, a range of sample sizes was estimated based upon the $W_i s_i$ for the months of July and August.

The degree to which the Fielding Lake data are representative of other burbot lakes will not be **known** until is conducted.

Question 6: Can burbot caught in hoop traps escape and if so, is the escape rate size biased?

Part of the experimental design in Fielding Lake was to examine the rate of escape, if any, from hoop traps. The null hypothesis was that all hurbot stayed in the traps once entering. The experiment to define this was conductec! during the July sampling and involved twenty traps in gear groups 6, 7 and 8 shown in Table *4*. Upon lifting hoop traps twice a day, captured burbot were measured, tagged, fin-clipped and returned to the same net. Escape of fish and handling effects were noted on subsequent lifts. Thirty-five burbot were handled and none escaped during **up** to four NN of fishing. **A** similar experiment was conducted during the September hoop netting period *(23* September-2 October). Nets set on 23 September were lifted and reset on *24* September with numbers of captured burbot noted. The nets were then lifted on 25 September and all fish were sampled, marked and released. The same procedure was followed between 25 and 27 September for 25 nets. Thrcr burbot escaped between *24* September and 26 a net with holes and one from an intact net. A net, lost between *24* September and 2 October was found to contain one of three burbot present on *24* September. These data indicate that burbot can escape nets but probably do so in limited numbers that can be minimized by frequent (2 NN) checks. Data are so limited concerning escaping burbot, that potential size bias cannot be adequately examined at this time.

Question 7: Do burbot exhibit deleterious effects from capture in hoop traps?

The initial experiment to assess handling effects was the same as that conducted during July to assess rate of escape. Twenty traps in gear group 6, 7 and 8 (Table *4)* wcrc set, lifted and reset twice a day. **The** *35* burhot captured were returned to the nets and observed for the test duration. One burbot (3%) died. Depths of set for these groups varied from 15' *(4.6* m) to *70'* (21.3 m) and averaged *42'* (12.6 m).

The above experiment, however, does not address all handling effects. It was sometimes observed that upon lifting a net and placing the captured burbot in a holding tub, within a few minutes they would show visible external hemorrhaging around the eyes, mouth, fin rays and anal vent. Periodically, the fish's stomach would extrude through the mouth, presumably due to internal pressure from gas bladder expansion, brought upon by the rapid decompression associated with trap lifting from depths of from 50 ft (15.25 m) to 74 ft (22.6 m) in Fielding Lake. When released, the fish that showed visible bloating signs often had difficulty in or were unable to descend. When fin clipping to assess tag loss, gas bubbles sometimes appeared at the incision. The above problems occurred less frequently in fish held less than approximately 5 minutes before release.

Bloating and hemorrhaging may have been effected by the temperature changes to which the fish were exposed. Fish captured in 50' and greater depths experienced a temperature increase during July of at least 7.6°F (4.3°C). Reducing this temperature shock by lowering holding tub temperatures and exposing the fish to as little surface time as possible may minimize handling effects and is addressed in greater detail in the Harding Lake data.

Harding Lake

Hoop net sampling for burbot was conducted on Harding Lake between 23-26 July 1985. Handling effects were noted on Fielding Lake during previous sampling, e.g. bloating and hemorrhaging. It was decided to sample Harding Lake to see if there was a similar occurrence, to identify the degree of handling mortality, and possibly develop techniques to ameliorate the problem.

A total of 147 net nights of sampling resulted in a catch of 60 burbot (Table 18). Mean CPUE was 0.408 burbot. The modal catch rate was 0.0 due to the high incidence of zero catches in the single net-night sets. Burbot captured in the 50-75 ft depth range and below showed an increasing level of mortality. Bloating was observed in fish captured in this stratum and below, as in Fielding Lake. The shallowest depth of noted mortality was 60 ft (18.3 m).

During the July 1985 research at Harding Lake, surface water temperature was about 20°C, whereas water temperature at 30 ft and below was less than 10°C. Burbot captured at depths of over 25 ft were generally held for a period of 1 to 2 days in a trap placed in about 30 ft of depth. To avoid temperature shock and better examine the effects of depth without compounding this problem with temperature shock, the tub In the boat was iced to reduce the water temperature while burbot were sampled and transferred to the holding trap.

On 25 July 1985, hoop trap catches from depths of 100 to 125 ft were treated differentially while sampling and transfer of captured burbot took place. Some traps were emptied. and the burbot (n=7) were placed in iced water. Burbot (n=4) from other traps were placed and transferred in surface water (20° C). Iced water ranged from 56°F (13°C) to 60°F

Table 18. Burbot summary catch and effort statistics for hoop traps fished in 6 depth strata, Harding Lake, 1985.

Strata	Depth (ft)	Total Effort (NN)[a]	Total Catch of Burbot	Mean CPUE[b]	Modal Catch	Minimum Catch	Maximum Catch
1	0 - 24	22	3	0.136	0.0	0.0	1.0
2	25 - 43	28	7	0.250	0.0	0.0	2.0
3	50 - 74	24	11	0.458	0.0	0.0	2.0
4	75 - 99	25	18	0.720	0.0	0.0	3.0
5	100 - 124	25	11	0.440	0.0	0.0	1.0
6	125 - 138	23	10	0.435	0.0	0.0	2.0
Total		147	60	0.408[c]	0.0	0.0	3.0

[a] 1 NN = 1 net night of effort (approx. 24 hours)

[b] Catch per 1 NN (approx. 24 hours)

[c] Weighted mean CPUE calculated as $\Sigma \frac{\text{(Strata Effort}}{\text{Total Effort}} \times \text{Stratum Catch)}$

(15.5° C). Burbot placed in cooled water suffered a *43%* mortality, whereas, burbot placed in surface water suffered a 75% mortality rate (Table **19**).

Although sample sizes were small, it is believed that cooling of holding tub temperatures helped control subsequent mortality. Fish captured below *50* ft *(15.2* m) were subjected to a 10 to 15°C temperature rise as the net was retrieved.

Additional data were collected on the rate in seconds required to lift certain traps in a single stage. In hope of gradually acclimating the fish to decreasing pressure and increasing temperature, three-stage lifts were conducted on five traps. The results, in addition to being labor-intensive, did not justify the effort as mortality rates were similar.

<u>Tanana River</u>

In 1985, a total of *998* burbot were caught during 653 net nights of hoop trapping (Table 20). Average CPUE values varied from 0.828 in Section 3 to 3.368 in Section 7. The modal catch varied from 0.0 in Section 5 during June and Section 6 during September, to 2.0 in Section **1** and Section 6 during August. Low modal values are due to a high frequency of zero burbot catches by traps in a section.

During *12-16* August, an experimental hoop net study was conducted in Section 2 of the Tanana River. The sample design and variables investigated were earlier described (Tables 6 and 7). Briefly, these were: 1) whether to rebait on daily net checks; 2) whether to move a trap daily when rebaited; 3) if not moved or rebaited, how long could the traps be left unattended without causing harm to captured burbot. The highest mean CPUE came from gear group C, where eight of the traps were checked, rebaited and moved daily (Table 21). Rebaiting and not moving group A traps resulted in almost the same mean CPUE *(0.84)* as in the once-baited and also not moved traps in group B (0.87). Due to the of zero catches (19 group A, 1[illegible] group B and 9 group C), the non-parametric Kruskal-Wallis test of catch per NN by gear group was conducted to test for differences in catches between groups (Table 22). The test indicates no significant differences between groups A and B, but does indicate significant differences between group A & B and group C ($P < 0.05$). The mean CPUE of nets moved and rebaited *(1.69)* is twice as high as the other groups indicating this to be the superior sampling method tested, assuming the goal is to maximize burbot catch. The catch by net-night (Table 23) indicate the highest catch occurred during the first net-night for two gear groups (48% group A, *46%* group B). Cumulative catch for group B simulates a standard multiple net-night set without rebaiting or moving. Catches declined in groups A and B, probably indicating a depletion of available fish in the immediate area regardless of bait condition. Except for the second

Table 19. Catch and mortality of Harding Lake burbot, 1985.

Depth Range	Iced	Burbot Catch	No. of Burbot: Released Alive	Mort.	Sacrif.	Mortality (%)
0-25 ft	No	3	3	0	0	0
25-50 ft	Yes	7	7	0	0	0
50-75 ft	Yes	11	9	2	0	18
75-100 ft	Yes	18	14	4	0	22
100-125 ft	Yes	7	3	3	1	43
	No	4	1	3	0	75
	Combined	11	4	6	1	55
125 ft plus	Yes	10	3	7	0	70
Total	Combined	60	40	19	1	32

Table 20. Burbot summary catch and effort statistics for hoop traps fished in 7 sections of the Tanana River, 1985.

Section	Dates Fished	Total Effort (1 NN[A])	Total Catch	Mean CPUE[C]	Modal Catch (per 1 NN[B])	Min Catch	Max Catch
1	1-4 October	84	199	2.369	2.0	0.0	12.0
2	12-16 August	96	109	1.135	1.0	0.0	8.0
3	29 July-2 Aug.	87	72	0.828	1.0	0.0	4.0
4	24-28 June	93	97	1.043	1.0	0.0	6.0
5	10-14 June	92	131	1.424	0.0	0.0	12.0
5	16-17 Sept.	12	14	1.667	0.5	0.0	4.0
6	8-12 July	95	135	1.421	1.0	0.0	8.0
6	5-9 August	63	156	2.476	2.0	0.0	11.0
6	19-20 Sept.	12	21	1.750	0.0	0.0	14.0
7	5-9 August	19	64	3.368	3.0	0.0	12.0
Totals		653	998	1.538[D]		0.0	14.0

[A] 1 NN = one net night of effort (approx. 24 hours)

[B] Catch per 1 NN (approx. 24 hours)

[C] Mean CPUE calculated as (Total Catch/Total Effort) = Catch/Trap/Net Night

[D] Weighted mean CPUE calculated as $\Sigma \frac{\text{(Strata Effort}}{\text{Total Effort}} \times \text{Strata Catch)}$

Table 21. Burbot catch and effort statistics for three experimental hoop trap gear groups, Section 2, Tanana River, 1985.

Gear Group	No. of Sets	Average Soak Time (Hours)	No. of Burbot Caught	Mean Burbot Catch	Modal Burbot Catch	Stratum Error of Mean Catch
A. Baited daily and not moved.	32	23.8	27	0.84	0	0.24
B. Baited once and not moved.	32	23.8	28	0.87	0	0.23
C. Baited daily and moved.	32	23.7	54	1.69	1	0.34

Table 22. Results from the non-parametric Kruskal-Wallis test of hoop trap catch per net-night by gear group for Section 2, Tanana River, 1985.

Gear Group	Total Effort[a]	Median Catch[b]	Avg Rank	Z Value
A	32	0.000	43.5	-1.23 (not significant)
B	32	0.000	43.5	-1.25 (not significant)
C	32	1.000	58.5	2.48 (significant at 5%)
Overall	96		48.5	

a = Net-nights, 1 NN = approx. 24 hours
b = Catch per 1 NN

Table 23. Catch by net-night for the experimental gear groups in Section 2, Tanana River, 1985.

Net Nights	Gear Group: A	B*	C
1	13	13	14
2	6	8	9
3	3	3	16
4	5	4	14
Total	27	28	54

* Cumulative catch for 2-4 net-nights, Group B

net-night, catches for group C either increased or remained stable, further confirming this as the better sampling method. Not rebaiting a group and moving was not tested, so the contribution of new bait as the cause for better catches in group C cannot be directly verified. However, as stated previously, rebaiting versus not baiting apparently had little influence upon catches in groups A and B.

The handling effects on burbot captured during the experimental netting program were tested by returning fish captured in groups A and B to the traps and noting their physical condition on subsequent lifts. After one net-night, 100% of the fish examined for damage (n=50) appeared in good condition. After two net nights, twenty-two (56%) looked healthy, 16 (41%) looked unhealthy and one died (3%). Ninety percent (27) examined after three net-nights looked poor but were released, while 3 (10%) died. None of the fish returned to the traps escaped. The major conclusion of this analysis is that rebaited traps moved daily with captured fish released appears to be the best sampling method.

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